

Global Solar Insolation Estimations at 1 Degree Resolution

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In this talk, we present an overview of the NASA Langley Research Center (LaRC) Surface Radiation Budget (SRB) Project Release 2 data set. This project run under the auspices of the World Radiation Climate Programme (WCRP)/Global Energy and Water Cycle Experiment (GEWEX) is primarily aimed at producing a climatology of global surface radiative fluxes in both shortwave (SW, 0.2–5.0 micrometers) and longwave (LW, 4.0–100 micrometers). Although, the primary objectives of the project are to provide fluxes for the atmospheric science and climate communities, a continuous long-term record of global solar insolation will provide data sets useful solar energy related and many other applications. The Release 2 data set is significantly upgraded from the Version 1.1 WCRP SRB SW 4-year data set (from which the commercial SSE Release 1 is derived) and the NASA LaRC 8-year data set. Among many

upgrades the most important are: the addition of a LW flux algorithms, the increase of resolution from 280 km to 1 degree equal angle, and the use of reanalysis meteorology from a data assimilation project. This Release 2 data set will provide SW and LW radiative fluxes for at least a 10 year climatology (1984–1993) over the globe at the 1 degree resolution. The fluxes will be produced at a variety of time scales including 3-hourly, daily, monthly and monthly averaged 3-hourly.

The WCRP/GEWEX SRB Release 2 data set is to be based upon the International Satellite Cloud Climatology Project's (ISCCP) "DX"

pixel level data set containing radiance and cloud retrieval information sample to a nominal resolution of 30 km. Previous SRB products from NASA LaRC used the ISCCP C1 level cloud and radiance data products that were processed to the 280 km equal area grid. The ISCCP "D" series data set represents an upgrade from the "C" series including the provision for ice cloud retrievals and better ice/snow determination. The pixel level ISCCP DX data set is averaged and processed to a 1 degree equal angle based grid system. This data set is also planned to be archived

and released. Many cloud and surface parameters relevant to surface insolation can be derived from these data. Besides the upgraded and higher resolution cloud and radiance data, several other new input data sets are used in Release 2 data set. The most important of these is the reanalysis meteorological data set used to supply temperature and humidity profile information and some relevant surface parameters. Other new data inputs include the 1.25 degree resolution TOMS Ozone data.

After presenting an overview of the upgrades described above, we show some preliminary results from limited processing. Regional and global distributions of surface SW fluxes will be presented and these fluxes will be compared with surface and satellite observations for validation. We will also provide an updated schedule for the archival and release of the new WCRP/GEWEX SRB Release 2 climatology data set.

WCRP/GEWEX Surface Radiation Budget Project

Global Solar Insolation Estimations at 1 Degree Resolution

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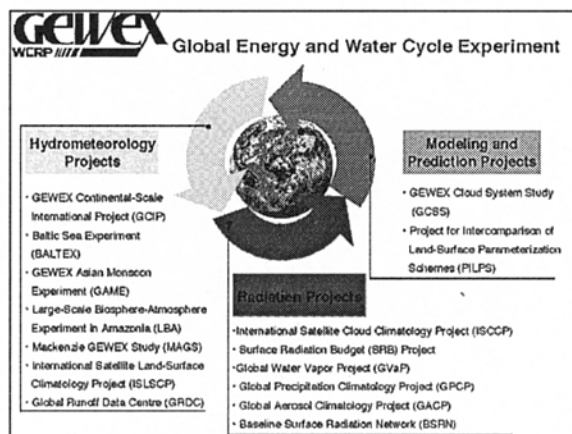
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Science Applications International, Corp.



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SRB Project Role Within WCRP/GEWEX



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SRB Project Objectives

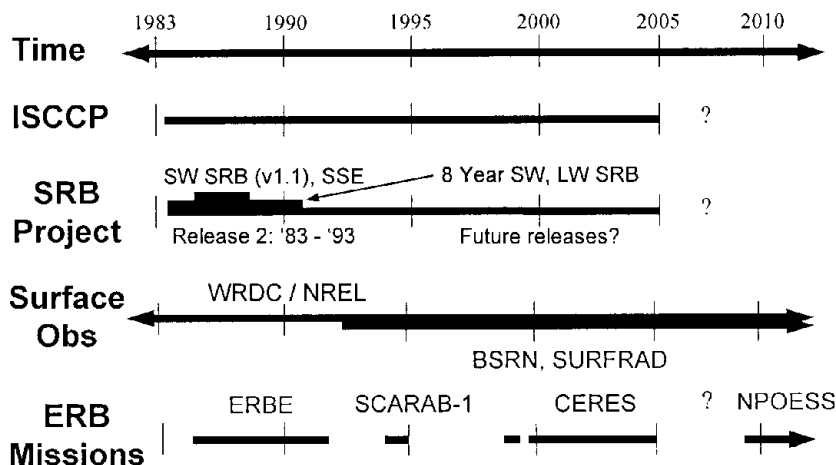
- Develop a high quality climatological data set of surface radiative flux quantities for research, industry, and education (WCRP/GEWEX data set).
- Evaluate the data set using surface observations, other SRB data sets (i.e., ISCCP SRB, CERES SARB) with the goal of developing methods of reducing errors and uncertainties.
- Analyze the data set to assess the climatology and sensitivity of radiative fluxes on a variety of spatial and temporal time scales.



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SRB Project Product Timeline



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SRB Project History

- **WCRP SRB (Release 1) and SSE:**

- *Outputs:* SW daily & monthly surface fluxes (280 km) for 1985 - 1988
- *Inputs:* ISCCP C1 (includes TOVS), ERBE Fluxes and ADM's, 5 climatological aerosols types
- *SW Algorithms:*
 - Pinker and Laszlo (1993): NB-BB conversion of ISCCP radiances to TOA fluxes using ERBE ADM's, Atmospheric Reflection/Transmission lookup table using Δ -Eddington 2-S; retrieves surface albedo, PAR and diffuse insolation.
 - Staylor (Darnell et al., 1988): Daily averaged SW insolation using broadband transmittance formulation w/ empirical fits of gaseous, aerosol absorbers, effective cloud transmittance; surface albedo retrieved from ERBE fluxes.



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SRB Project History

- **NASA LaRC 8 Year SRB:**

- *Outputs:* SW & LW daily & monthly surface fluxes (280 km) for 1983 - 1990
- *Inputs:* ISCCP C1 (+TOVS), ERBE Fluxes and ADM's, 5 climatological aerosols
- *Algorithms:*
 - SW - Staylor
 - LW - Gupta (1992): RT based parameterizations for clear/cloudy downwelling LW flux weighted w/ cloud fraction, reanalysis meteorology, CERES surface emissivity



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SRB Project Goals for Release 2

- Provide global surface and top-of-atmosphere radiative fluxes plus relevant input parameters at 1 degree equal angle resolution.
- Provide flux quantities at 3-hourly intervals and averages of 3-hourly monthly, daily, and monthly.
- Meet the following accuracy criteria (RMS error):

Flux Quantity	SW Error (W m ⁻²)	SW % Error (195 W m ⁻²)	LW Error (W m ⁻²)	LW % Error (327 W m ⁻²)
3-hourly	40	20	35	11
Daily	30	15	25	8
3-hourly Monthly	20	10	20	6
Monthly	15	8	15	5



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WCRP/GEWEX SRB Release 2

- **Inputs:**
 - ISCCP DX:
 - sampled VIS/IR radiances; retrievals of cloud and surface quantities (30 km nominal resolution)
 - averaged to 1 degree (equal angle) based grid similar to CERES SARB (processed at LaRC DAAC; discussions w/ ISCCP to make new output product)
 - DAO GEOS-1 (or ECMWF) reanalysis: P, T, q profiles
 - TOMS Ozone Data (nominal 1.25° resolution)
 - ISCCP Ice/Snow maps (1° resolution)
 - CERES Surface Characterization Maps
 - Climatological Aerosol Maps: evaluating Global Aerosol Data set w/ RH dependence (Koepke *et al.*, 1997, BAMS)



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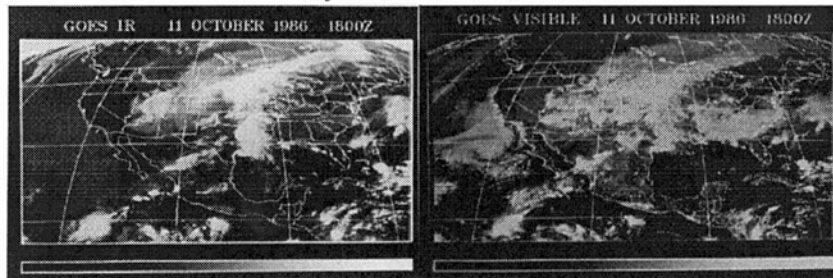


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SRB Gridded Inputs: Infrared and Visible Images from GOES

ISCCP combines the GOES, METEOSAT,
and GMS Geostationary Satellites with NOAA
POES AVHRR observations every 3 hours from
July 1983 through at least the year 2000.

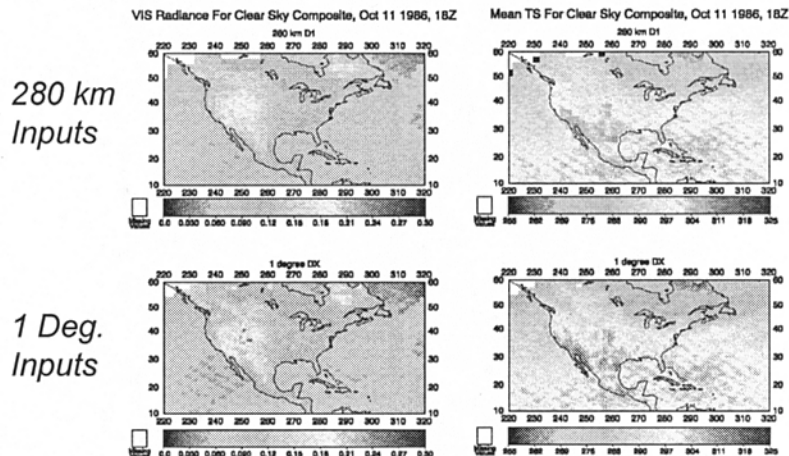
Case Study: GOES 11 October 1986



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SRB Gridded Inputs: Visible Radiances and Skin Temps

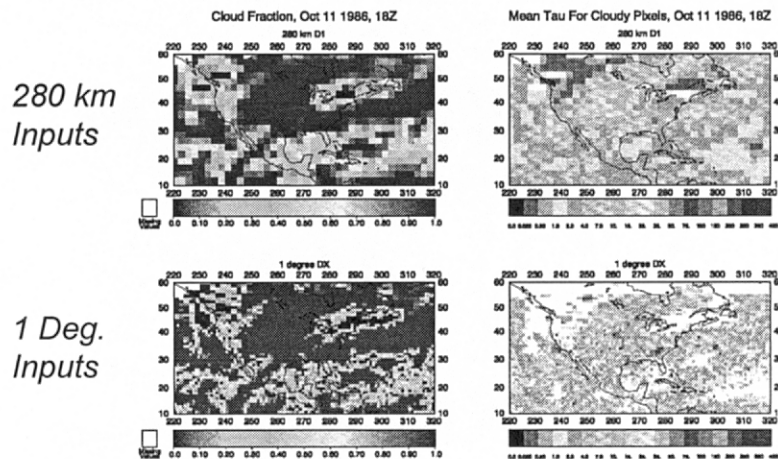


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SRB Gridded Inputs: Cloud Fraction and Optical Depth



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WCRP/GEWEX SRB Release 2

• Algorithms:

1. GEWEX SW (Pinker-Laszlo) - Δ -Eddington 2-S based method
2. GEWEX SW QC (Staylor) - physical-empirical method
3. GEWEX LW (Stackhouse) - uses CERES LW 2/4 S RT model (Fu et. al., 1997), random cloud overlap, non-black surfaces, reanalysis meteorology, CERES spectral surface emissivity.
4. GEWEX LW QC (Gupta, 1989, 1992) - RT based parameterizations for clear/cloudy downwelling LW flux weighted w/ cloud fraction, reanalysis meteorology, CERES surface emissivity

• Outputs:

1. Surface and TOA flux quantities provided on 3-hourly, daily, 3-hourly monthly, and monthly basis
2. 1 degree equal-angle output products (fluxes plus intermediary)
3. Specialized data subsets for users



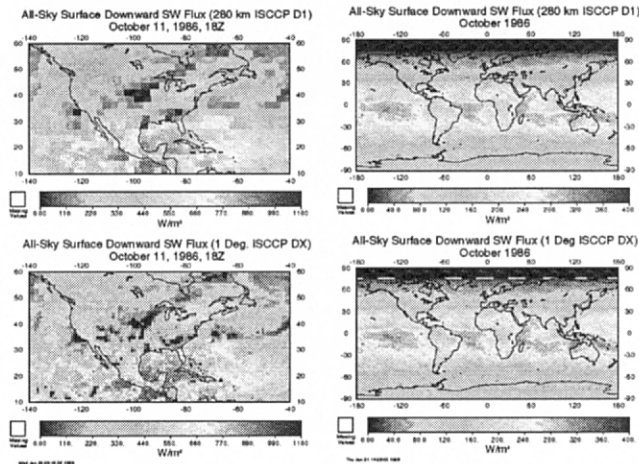
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SRB GEWEX SW (Pinker/Laszlo) Fluxes: One time & Monthly Averaged

280 km
Outputs



1 Deg.
Outputs

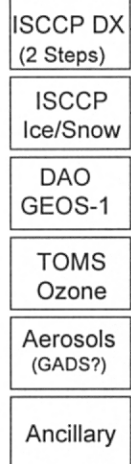


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SRB Project Data Flow (Release 2)

Inputs



Outputs

SRB/TOARB
Processing:
GEWEX SW
GEWEX LW
SW QC
LW QC

1 Degree Cloud/
Atmos/Surface
Input Products

Spatially Averaged/
Specialized Subsets

3-Hourly
Gridded

3-Hourly
Monthly
Gridded

Daily
Gridded

Monthly
Gridded



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SRB Project Validation

- **Input Parameter Sensitivities/Processing Errors**
 - calibration uncertainties for input data sets (i.e., radiance)
 - sampling/gridding/filling errors
 - uncertainties of derived parameters (i.e., cloud retrieval errors, atmospheric profile errors)
 - water vapor sensitivities: comparisons in collaboration w/ University of Maryland (R. Pinker).
 - polar cloud properties TOVS vs ISCCP DX Gridded in collaboration w/ Rutgers University. (J. Francis)



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SRB Project Validation

- **Surface Observations**
 - process surface observations (WRDC, BSRN, NOAA CMDL, local networks) to temporal scales comparable to output
 - typical comparisons to observations involve matching monthly averaged surface observations to calculated fluxes
 - explore relationships between parameters
 - improvements/enhancements to comparisons
 - address temporal/spatial mismatches
 - provide measure of variability of time series (higher moment statistics, histogram, correlation)
 - characterization by climate region and/or atmospheric condition
- **Other SRB Data Sets**
- **ERBE TOA Flux Observations**



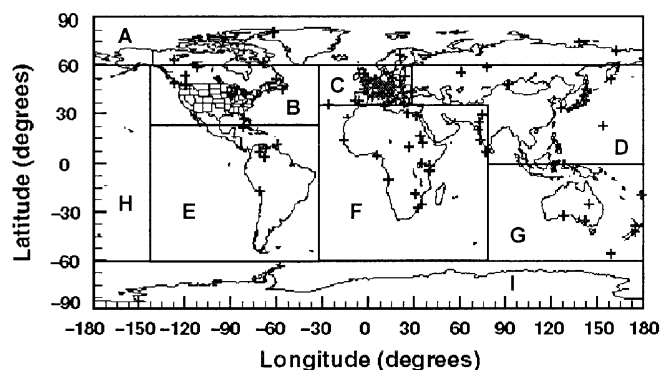
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SRB Project Validation

- Surface sites from the Global Energy Balance Archive (subset of WRDC surface sites) and FIRE I in 1986.
- Analysis performed by latitude, regions (see below), and surface types



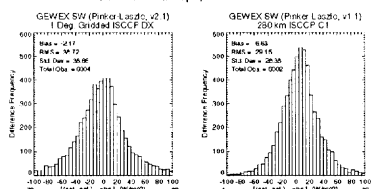
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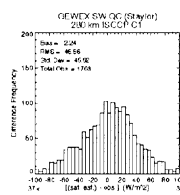
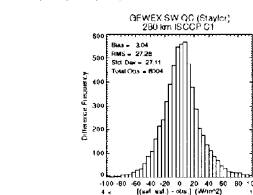
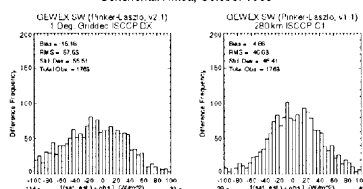
SRB Validation Plan

- Statistical analysis of the daily averaged differences by regions

Estimated Daily Averaged Downward Surface Shortwave
Flux Differences from Surface Measurements
Continental Europe, October 1986



Estimated Daily Averaged Downward Surface Shortwave
Flux Differences from Surface Measurements
Continental Africa, October 1986



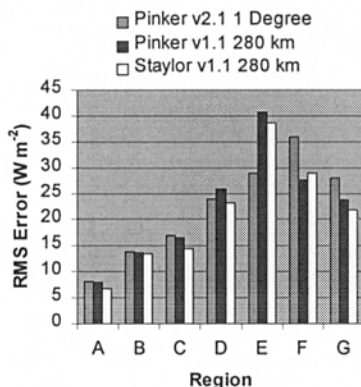
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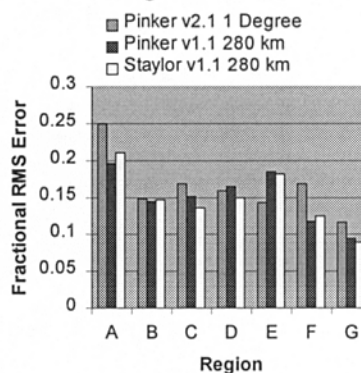
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SRB Project Validation

Monthly Averaged SW
Insolation RMS Errors



Monthly RMS Error of SW
Insolation as Fraction of
Average Solar Irradiance



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SRB Project Aerosol Activities

- **Release 2 Aerosol Strategy:**
 - evaluate Global Aerosol Data Set (GADS) of Kropke *et al.*, (1997) in collaboration w/ Dr. R. Pinker's group at UMd.
 - GADS includes haze type parameterizations using relative humidity
- **Archive biomass burning smoke likelihood maps:**
 - completion of biomass emissions maps using DMSP and smoke trigger parameterization from GPCP data
 - supplement with remote sensing from ISCCP DX, TOMS, etc.
 - Trajectory modeling with NASA LaRC Trajectory Model (LTM)
- **Release 3 Aerosol Strategy:**
 - participate in Global Aerosol Climatology Project (GACP)
 - use background aerosol maps with biomass burning aerosol maps

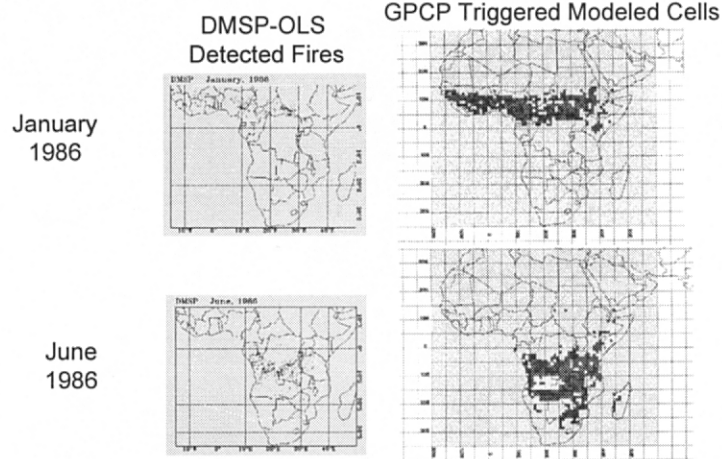


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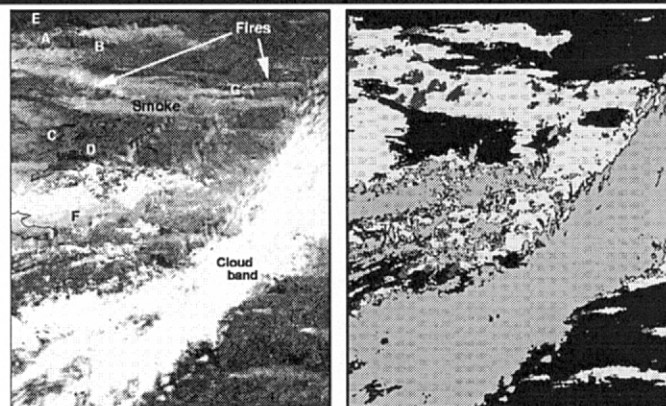
Biomass Burning Aerosols from DMSP



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Biomass Burning Aerosols from AVHRR



False color image formed from:

Red: BT (3.7 - 11 μm)
Green: 0.83 μm reflectance
Blue: 11 μm brightness temperature

clear cloud smoke fire

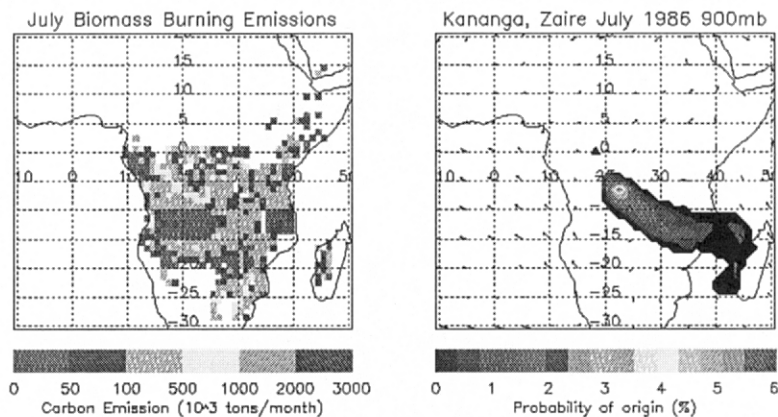


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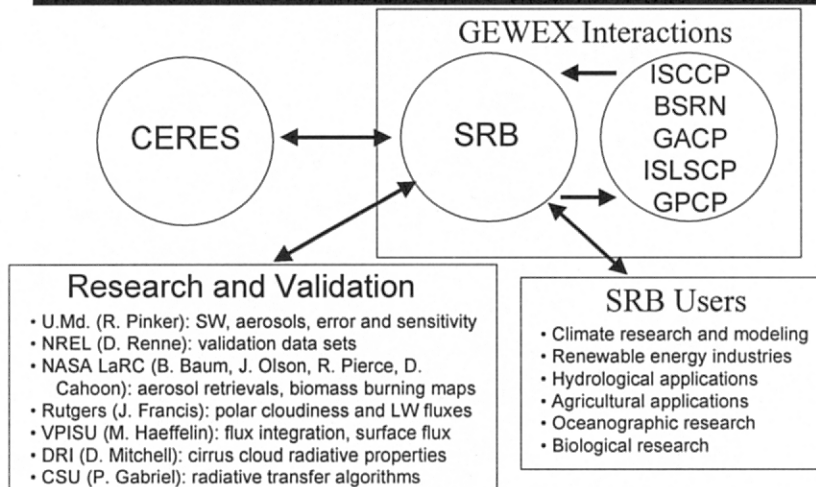
Biomass Burning Aerosols from Trajectory Modeling



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SRB Collaborative Relationships



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Summary

- **Present Activities**

- preparing for release 2 of WCRP/GEWEX SRB
 - evaluation of ECMWF and GADS
- collection/analysis validation data sets
- sensitivity/validation tests
 - develop collaborative relationships w/ other investigators

- **Near Future**

- Archival/documentation of Release 2 data sets
- Sensitivity/Validation w/ surface observations and other SRB data sets



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WCRP/GEWEX SRB Release 2: Current Schedule

- **Initial Test Months: August, 1999**
 - evaluate GEOS-1 and compare to ECMWF
 - background aerosol distributions
 - complete adaptation of algorithms for new inputs
 - process and validate 8 test months for surface and top-of-atmosphere fluxes
- **Initial Two Test Years: October, 1999**
 - process and validate two test years
 - algorithm sensitivity testing
 - archive data sets
- **Process Remaining Years: March, 2000**
 - validate where/when possible
 - archive product data sets



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